SYNCRANIAL OSTEOLOGY OF *ARCTOCEPHALUS GAZELLA* (PINNIPEDIA, OTARIIDAE) FROM RIO GRANDE DO SUL, BRAZIL

César Jaeger Drehmer[1]
Larissa Rosa de Oliveira[2]

ABSTRACT

A syncranial description and morphometrics, as well as absolute ages, of one adult female and two subadult males of the Antarctic or Kerguelen fur seal *Arctocephalus gazella* (Peters, 1875), recovered in 1994, are presented. Osteological and tooth characters are discussed with the congenerics species *A. australis* (Zimmermann, 1783) and *A. tropicalis* (Gray, 1872), also occurring in southern Brazil. *A. gazella* shows reduced and simplified post-canine dentition, including a strong wear at lingual surfaces.

KEYWORDS. Otariidae, *Arctocephalus gazella*, syncranium, craniometrics, osteology.

INTRODUCTION

Arctocephalus G. Saint-Hilaire & Cuvier, 1826 is an otariid genus with eight species, six from southern hemisphere (Croxall & Gentry, 1987), but only three occurring in Brazil, specially in the Rio Grande do Sul State coast. The southern fur seal, *A. australis* (Zimmermann, 1783) is the most abundant and widespread species along South America coast. In Brazil, it is frequent during winter and spring (Simões-Lopes **et al.**, 1995). The subantarctic or Amsterdan fur seal, *Arctocephalus tropicalis* (Gray, 1872), haul out and breeds north to the Antarctic Convergence in the South Atlantic and Indian oceans, mostly on the subantarctic islands of Amsterdan, Saint Paul, Prince Edward, Marion, Crozet, Macquaire and Tristan da Cunha, and occurring along the Rio Grande do Sul with highly variable frequencies along the years. The Antarctic or Kerguelen fur seal, *Arctocephalus gazella* (Peters, 1875), inhabits mainly islands south to the Antarctic Convergence and north to latitude 65° S in the Atlantic and Indian sectors of the southern hemisphere (Bonner, 1981), although some colonies (Marion, Crozet and Macquaire Islands) lie north to the Convergence (Jouventin **et al.**, 1982). The occurrence of this species in Brazil is very uncommon. The first record was based on two specimens found dead along the Rio Grande do Sul coast in 1984 (Pinedo, 1990).

1. Universidade Federal de Pelotas. C.P. 354, CEP 96010-900, Pelotas, RS, Brasil. (cdrehmer@ufpel.tche.br).
2. GEMARS - Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul. Rua Felipe Neri 382/203, CEP 99440-150, RS, Brasil. (lari@pucrs.br).

KING (1959) established the differences between *A. tropicalis* and *A. gazella* (both considered as *A. tropicalis* subspecies at that time), based on osteological and soft parts characters. REPENNING **et al.** (1971) presented the revision of *Arctocephalus* species, using skull characters. Here a syncranial description and morphometrical analysis of three specimens of *A. gazella* are presented and discussed with its congenerics *A. tropicalis* and *A. australis*.

MATERIAL AND METHODS

The three specimens were collected during field work along 270 km of beach in southern Brazil, from Torres (29° 19'S, 49° 43'W) to Parque Nacional da Lagoa do Peixe (31°21'S, 51°02'W), in northern Rio Grande do Sul coast, an area regularly surveyed from 1991 to 1998. The skulls were deposited in the osteological collection of Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul GEMARS (GERS), Porto Alegre, RS, Brazil. No postcrania was collected.

The osteological preparation was similar of that described by DREHMER & FERIGOLO (1996a, b). The sex determination was done in the field. The age classes were determined using the criteria proposed by SIMÕES-LOPES **et al.** (1995) and DREHMER & FERIGOLO (1997), and the absolute age was determined following the method described by ROSAS **et al.** (1993), by the counts of the growth layer groups (GLG's) of dentine (IWC, 1980). The skull and dentary measurements followed KING (1959) and DREHMER & FERIGOLO (1997). The terms, closed, fused and opened, were used according to DREHMER & FERIGOLO (1997). The sutures referred in parenthesis and clasps were modified from MILLER **et al.** (1964), to emphasize bone parts. Abbreviations: Ac, age class; I, incisives; GMRS, GEMARS, Grupo de estudos de mamíferos aquáticos do Rio Grande do Sul; PC-/, upper postcanines; PC/-, lower postcanines; RS, Rio Grande do Sul.

Material examined. BRAZIL. **Rio Grande do Sul** coast: 30°30'S, 50°20'W, adult ♀, 08.VIII.1994; 30° 42'S, 50° 29'W, subadult ♂, 10.IX.1994; 29°52'S, 50°04'W, subadult ♂, 11.IX.1994; D. Danilewicz & M. Martins col. (GMRS 189, 199, 209, respectively).

RESULTS AND DISCUSSION

Skull measurements (tab. I). Adult female (figs. 1, 2, 7, 10-13, GMRS 189). Ac 3. Absolute age 11 years. The skull presents closed and fused basicranium sutures [basioccipito-basisphenoid (=sphenoccipital or basal) and basisphenoid-presphenoid (=intersphenoidal)], and palatal ones [intermaxillary, interpalatine and palatino-maxillary (=palatomaxillary)] closed but not fused (fig. 7). The zygomatic arch sutures are at different maturity stages, the jugo-maxillary (=zygomaticomaxillary) fused, the jugo-squamosal (=temporozygomatic) opened (fig. 2) and the premaxillo-maxillary (=incisivomaxillary) partially fused. The sutures of skull roof, interfrontal, interparietal (=sagittal) and parieto-frontal (=coronal), closed; the sagital crest absent and the dorsal nuchal ones well developed (fig. 1) and the ventral nuchal crest extremely well developed (figs. 1, 2). The mastoid processes developed but little pronounced (typical female) (fig. 7) and the mastoid ossicles very well developed and completelly fused (fig. 2). The tympanic bulla with a visible entotympanic (fig. 7); its lateral portion presents a very conspicuous rounded vagina process styloidei. The maximum width between postcanines at PC5/ level. This specimen, anomalously, does not present PC6/. The right posterior palatine foramen is at the vertical lamina of the palatine bone, at the level of the palatino-maxillary suture, whereas the left one included in the horizontal lamina of the palatine. The maxillary shelf (ventral root of the zygomatic arch) well developed (fig. 7), and the lacrimal bones fully fused to the maxillary preorbital processes.

The dentition is partially preserved: right I1-2/, PC1/, 3-5/ and I/1 and left I2/,

Table I. Syncranial measurements (in mm) of *Arctocephalus gazella* specimens from RS. 1, condylo-basal length; 2, orbital length; 3, rostral width; 4, interorbital width; 5, postorbital constriction width; 6, skull width; 7, basioccipital width; 8, jugo-squamosal suture length; 9, width of the ventral root of the zygomatic arch; 10, palate width at PC6/; 11, dentary length; sa, subadult.

Specimens (GMRS)	1	2	3	4	5	6	7	8	9	10	11
189 (♀)	194.0	55.8	34.0	24.5	32.4	101.2	34.7	26.7	12.8	30.9	125.4
199 (♂ sa)	195.0	53.8	36.6	25.0	33.7	98.2	31.4	17.1	14.7	29.0	118.0
209 (♂ sa)	194.1	54.8	38.8	27.5	36.7	104.5	34.1	20.0	15.3	34.0	120.3

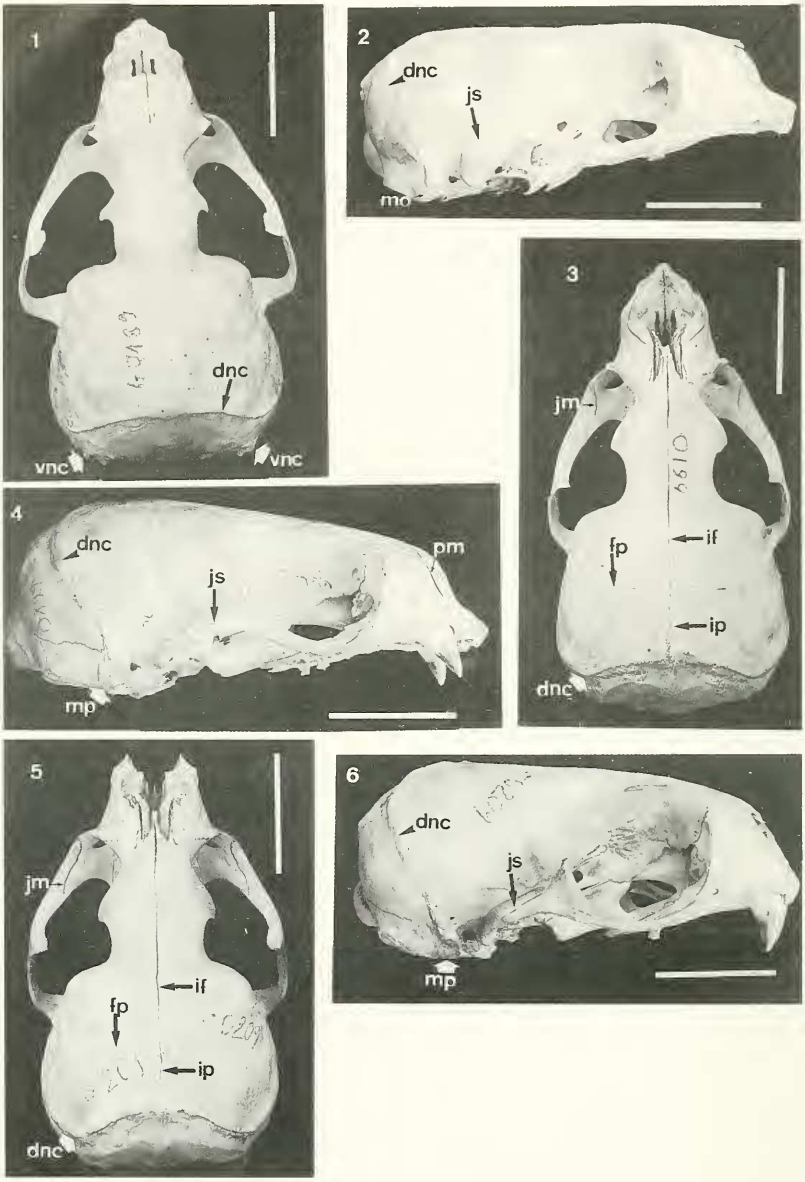
PC3-4/, I/1 and PC/4 absent. The postcanines present a very conspicuous triangular wear at the lingual surface, extending from the crown basis up to the principal cusp apex. In the lower postcanines, the wear surface is smaller than in the upper ones. The left PC5/ crown reduced to a little button with a strong wear and its double root strongly curved, one anteriorly and another posteriorly. A well developed diastema between PC4/ and PC5/ as well as between PC/4 and PC/5 (fig. 7). Both PC6/ absent, with no signs of alveoli, what characterizes a dental anomaly (fig. 7). The upper canines show strong wear at its lingual portion.

In the dentaries (figs. 10-13, GMRS 189) the coronoid, condyloid and angular processes well developed; at the ventral border of dentary body, at the level of PC/3-4, there is a knob-like process here called "dentary body process" (figs. 10, 12).

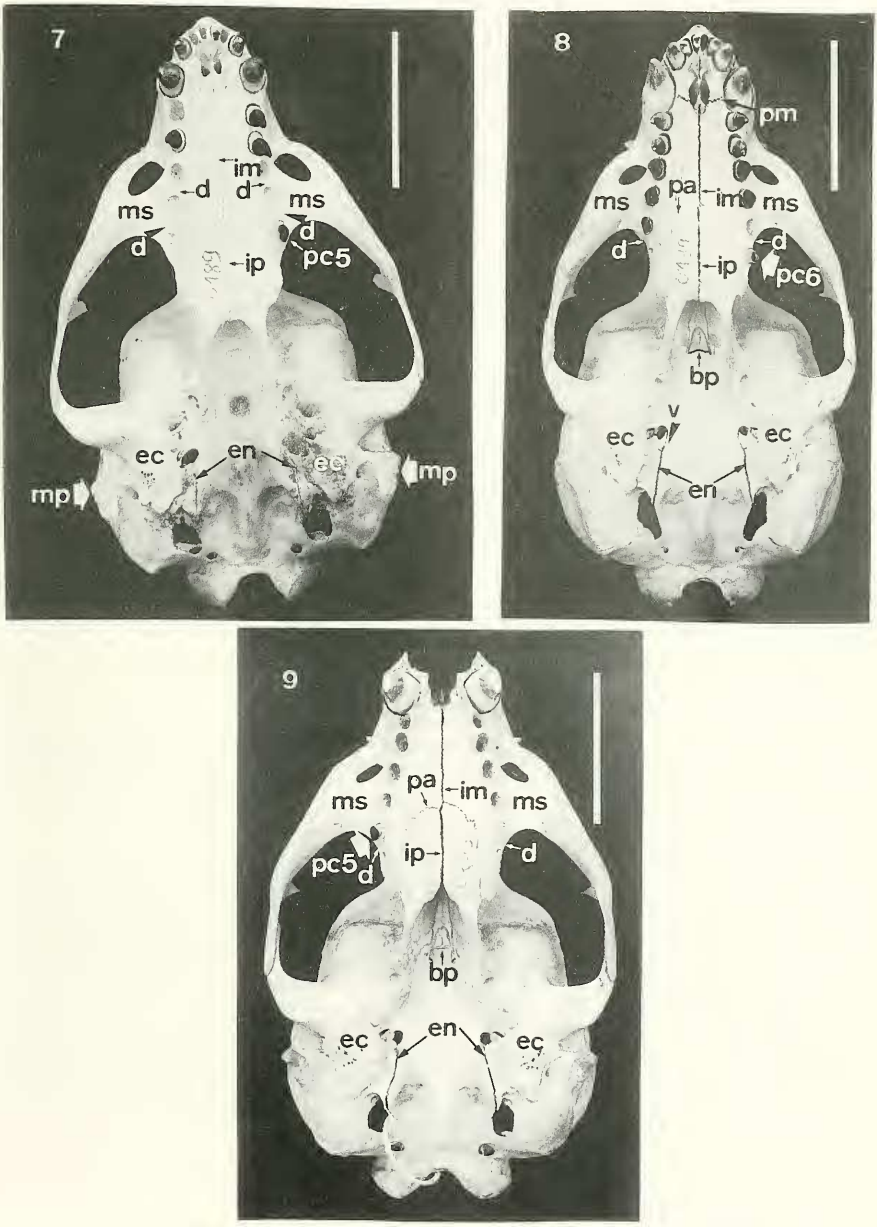
Subadult male (figs. 3, 4, 8, 10-13, GMRS 199). Ac 2. Absolute age 2 years. In the skull the nasals (fig. 3) and pterygoids (fig. 8) are lost; the basal suture almost completely fused, only being seen near to the entotympanics, and the basisphenoid-presphenoid suture opened (fig. 8). The skull roof sutures closed but not fused, except from the occipito-parietal; the sagittal crest absent and the dorsal nuchal one poorly developed (fig. 3). The palatal and zygomatic sutures opened as well as the premaxillo-maxillary (figs. 3, 4, 8). The mastoid processes poorly developed, and the mastoid ossicles partially fused (fig. 4). The entotympanics completely visible in palatal view (fig. 8). Like other specimens, the maximum length of the secondary palate at the PC5/. The posterior palatine foramina, rounded little openings on the ventral border of the orbital vacuity, formed by the vertical lamina of the palatines. The maxillary shelf well developed (fig. 8) and the lacrimal bones completely fused to the preorbital processes.

In the dentition, right PC6/ and I/1, left I1/ and PC5/, absent. The lower canines partially erupted, the base of the crown still inside the alveoli, and no wear was found (figs. 10-13, GMRS 199). The postcanines show different degrees of lingual wear. The more important wears are the left PC2/ and PC4/. The right PC5/ and left PC6/ show reduced wear with double roots latero-medially strongly curved, mainly in the first one. Despite of their absence, and as shown by alveolar morphology, left PC5/ and right PC6/ present the same root morphology as described above. The PC/5 double root does not present the typical curvature observed in the upper ones.

In the dentaries (figs. 10-13, GMRS 199) all the processes well developed and the canines partially erupted, corroborating its age class. The mentonian foramina present at lateral view (figs. 11, 13).



Figs. 1-6. *Arctocephalus gazella* skull. GMRS 189: 1, dorsal view; 2, lateral view. GMRS 199: 3, dorsal view; 4, lateral view. GMRS 209: 5, dorsal view; 6, lateral view (dnc, dorsal nuchal crest; fp, fronto-parietal suture; jm, jugo-maxillary suture; js, jugo-squamosal suture; if, interfrontal suture; ip, interparietal suture; mo, mastoid ossicle; mp, mastoid process; pm, premaxillo-maxillary suture; vnc, ventral nuchal crest). Scales 50 mm.



Figs. 7-9. *Arctocephalus gazella* skull, palatal view: 7, GMRS 189; 8, GMRS 199; 9, GMRS 209 (bp, basisphenoid-presphenoid suture; d, diastema; ec, ectotympanic; en, entotympanic; im, intermaxillary suture; ip, interpalatine suture; mp, mastoid process; ms, maxillary shelf; pa, palatino-maxillary suture; pc5, fifth postcanine; pc6, sixth postcanine; pm, premaxillo-maxillary suture; v, vestige of basal suture). Scales, 50 mm.

Subadult male (figs. 5, 6, 9, 10-13, GMRS 209). Ac 2. Absolute age 2 years. The premaxillae, nasals (fig. 5) and pterygoids (fig. 9) absent. The basal suture fused and the basisphenoid-presphenoid one closed but not fused (fig. 9), in the same way the sutures of the skull roof (fig. 5). The palatal (intermaxillary, interpalatine and palatino-maxillary) and zygomatic sutures opened (figs. 6, 9). The dorsal nuchal crest poorly developed and the sagittal one absent (fig. 5). The mastoid processes poorly developed as well as the mastoid ossicles (fig. 6). In the tympanic bulla the ectotympanic and basisphenoid bones little overlap the entotympanics (fig. 9). The secondary palate presents its higher width between the PC5/. The posterior palatine foramen is a rounded little opening included in the horizontal lamina of the palatine bone, in both sides. The maxillary shelf very well developed (fig. 9) and the lacrimal bone has the same morphology as described formerly.

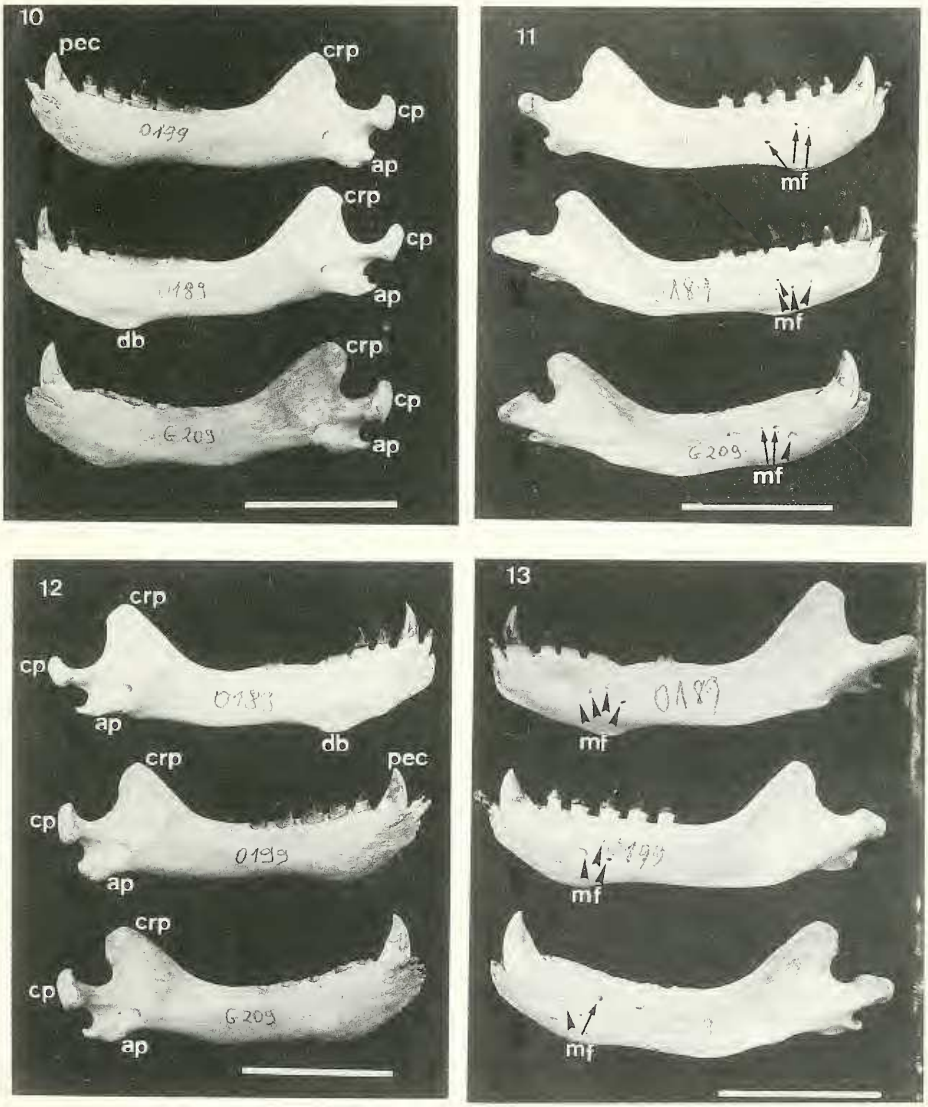
In the dentition, only 4 without wear canines and the right PC5/ preserved; the latter one having a reduced button-like crown with a vestigial central cusp (fig. 9), the double root being strongly lateromedially curved.

In the dentaries (figs. 10-13) all the processes present the species pattern, and in the left one, there are two large mental foramina, and other ones of smaller diameter (fig. 13).

The postcanine dentition of *A. gazella* represents the extreme degree of tooth reduction and simplification for the genus *Arctocephalus*, a derived condition (apomorphic) (DREHMER & FERIGOLO, 1996b) when compared to *A. australis* and *A. tropicalis*, and the other five species (REPENNING **et al.**, 1971:6) cusp pattern. PAYNE (1979:96) argued that a krill (*Euphausia superba* Dana, 1850) diet can explain this dental morphology and suggested that the "... Antarctic Convergence is a significant environmental boundary in respect to the feeding ecology of these two species [*A. gazella* and *A. tropicalis*], at least during the summer". We suggest that this diet is a consequence, and not the cause, of a reduced and simplified dentition, resulting from a different process envolving a paedomorphic trend in the evolution of *A. gazella*, corroborating DREHMER & FERIGOLO, 1997. Still, corroborating this interpretation, an antarctic seal species, *Lobodon carcinophagus* Hombron & Jacquinot, 1842 a krill eater, has a dental morphology quite different from *A. gazella*, with the cusps well developed.

The specimen GMRS 189 presents abnormal numeric reduction in the dental formula by agenesis of PC6/. Dental anomalies and pathologies were referred for *A. australis* and *A. tropicalis* from the Rio Grande do Sul (DREHMER & FERIGOLO, 1996b). There is no information in what concernes the frequence of such anomalies in the populations, but the records indicate that they seem more frequent than suspected before. Dental and mandibular injuries were reported (ERB **et al.**, 1996) in an adult male "Antarctic fur seal" from Heard Island. Taking into account the condylo-basal length (250 mm) and the absence of a well developed sagittal crest, that is typical of the male, the specimen of ERB **et al.** (1996) seems to be an otariine rather than an arctocephaline (**sensu** BERTA & DEMÉRÉ, 1986). The pathologies described by them are another evidence of the great exposition to trauma that the otariids in general are submitted, whose consequences (e. g. osteomyelitis) can lead to death. These traumatic events are fights related or not to female retention by males as well as juvenile play behavior.

The triangular-shaped strong lingual wear in the upper postcanines, present in specimens here examined, corresponds to "a very conspicuous abrasion surfaces on the medial surfaces of the upper postcanine teeth" referred by REPENNING **et al.** (1971) and represents another apomorphy for *A. gazella* within *Arctocephalus*.



Figs. 10-13. *Arctocephalus gazella* dentaries right: 10, medial view; 11, lateral view; left: 12, medial view; 13, lateral view (ap, angular process; cp, condyloid process; crp, coronoid process; mf, mentonian foramina; pec, partially erupted canine; db, dentary body process; 189, 199, 209 are the GMRS numbers). Scales 50 mm.

The three mensurable skull characters presented by KING (1959) to distinguish *A. tropicalis* from *A. gazella*, length of the jugo-squamosal suture (ranging from 10.8 to 14.6 mm), the width of the lower zygomatic root of the maxilla (ranging from 7.3 to 9.5 mm) and the palate width at PC6/ (ranging from 14.9 to 17.9 mm) differ from our data (see tab. I), concerning *A. gazella*, in spite of the fact that measurements of only three specimens were accomplished. KERLEY & ROBINSON (1987:129), excluded both the jugo-squamosal suture length and the zygomatic root width from their study, since they considered such measurements as "unsuitable for taxonomic purposes due to high intraspecific variation or interspecific overlap".

Concerning six non-mensurable characters presented by DREHMER & FERIGOLO (1997:144-5) for *A. australis* and *A. tropicalis*, *A. gazella* is more similar to the first one in two characters, what might indicate a close relationship between them: 1) the tympanic bulla morphology (entotympanic visible in palatal view); 2) upper teeth row little divergent posteriorly with maximum width at PC5/ level. Other two characters can be considered 'intermediary' between *A. tropicalis* and *A. australis*, according to DREHMER & FERIGOLO (1997): 1) the posterior palatine foramen position, slit-like at the horizontal lamina of the palatine bone like in *A. tropicalis*, or rounded and situated at the vertical lamina of the palatine bone, like in *A. australis*; 2) the foramen for an infraorbital artery/nerve ramus situated anteriorly to the infraorbital foramen.

The development of nuchal and sagittal crests, analized by DREHMER & FERIGOLO (1997), can not be here considered, except in the adult female with a very well developed nuchal dorsal crest, because the other two specimens are subadults. The measurement ranges expressed as a percentage of the condylo-basal length (DREHMER & FERIGOLO, **op. cit.**) are not useful because their data refer to adult males, absent in our study.

Another point to be considered is the probable hybridism between *A. gazella* and *A. tropicalis* verified at Prince Edward Island (CONDY, 1978). KERLEY & ROBINSON (1987) using skull morphometrics constructed phenograms that showed the interespecific relationships between *A. tropicalis* and *A. gazella*, with hybrids' data falling between them; their sample included only adult males and this makes impossible a comparison with our data. So, if the hybridism really occurs, the osteological analisys are subject to a higher degree of variation. Despite this, the specimens here examined, permited to recognize *A. gazella* typical characters, main one being reduction and simplification of the postcanine teeth.

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